Deepwater Horizon / Mississippi Canyon 252 Oil Spill Natural Resource Damage Assessment

TECHNICAL REPORT: QUANTIFICATION OF FLEDGLINGS LOST IN 2010

Prepared by the U.S. Department of the Interior, Fish and Wildlife Service

August 2015

1 INTRODUCTION

The *Deepwater Horizon* / Mississippi Canyon (MC 252) Oil Spill ("spill") began in late April 2010 in the northern Gulf of Mexico. The Department of the Interior ("Department") bureaus responsible for the management and protection of avian resources (i.e., the U.S. Fish and Wildlife Service and the National Park Service), together with the states of Florida, Alabama, Mississippi, Louisiana, and Texas (collectively referred to as the "Natural Resource Trustees") evaluated oil spill-related injuries to birds.

One type of natural resource injury pertaining to birds was mortality due to the spill. During the *Deepwater Horizon* (DWH) spill, the Trustees collected and counted dead birds and live debilitated birds found in the spill-affected area. Information on collected carcasses and live debilitated birds was incorporated into injury quantification models used to assist the Trustees in estimating the total avian mortality, such as the Shoreline Deposition Model (IEc 2015a). The Shoreline Deposition Model and Lost at Sea Factor (herein referred to as simply the "Shoreline Deposition Model"), along with the Excluded Regions methodology (USFWS 2015b), estimated the portion of avian mortality that occurred in the nearshore area of the northern Gulf of Mexico between the start of the spill and October 1, 2010 using information on bird collections, search effort, searcher efficiency, and carcass persistence. However, the quantification of fledglings lost in 2010 due to the DWH spill may be incompletely addressed by these mortality estimation methods. This document explains the Department's preferred approach to quantifying lost 2010 fledglings.

The ultimate goal of this document is to provide a quantification of the loss of fledglings that were hatched (or that would have been hatched) in 2010. This report briefly evaluates the data that were available and the resulting feasible methods to estimating lost 2010 fledglings. The analysis concluded that the preferred method is an estimation based upon the quantified adult mortality derived from other nearshore DWH mortality estimation models. The report also discusses the uncertainties and limitations involved with the preferred method. The fate of birds between fledging in 2010 and reaching one year of age, and the associated natural resource injury, if any, are not assessed in this report. A quantification of fledglings lost in 2011 is provided by the technical report *Quantification of Fledglings Lost in 2011* (USFWS 2015c).

2 BACKGROUND

Effects of the oil spill occurred during the 2010 avian breeding season (which roughly occurs March through August in the northern Gulf of Mexico) and beyond. The productivity of breeding birds in 2010 and the survival of their fledglings could have been adversely impacted in the following ways:

1. Oiled breeding adults could have been sickened so that gametes were nonviable, producing an abnormally high number of nonviable eggs laid or smaller than normal clutch sizes. The resulting natural resource injury would be chicks not produced.

2. Oiled breeding adults could have transferred oil to viable eggs in the nest while incubating them, causing the eggs to smother in oil or become nonviable due to oil toxicity. The resulting natural resource injury would be egg mortality.

3. Oiled breeding adults could have transferred oil to hatched chicks through physical contact, exposing chicks to oil toxicity. The resulting natural resource injury would be chick mortality or reduced fitness.

4. Breeding adults could have fed chicks contaminated prey that could have caused toxic effects in the chicks. The resulting natural resource injury would be chick mortality or reduced fitness.

5. Breeding adults could have died from spill-related causes at any time during their breeding cycle, leaving eggs or chicks less able to survive. The resulting natural resource injury would be chick/egg mortality.

6. Pre-fledging chicks could have been exposed to oil in their environment while loafing outside their nests, causing toxicity. The natural resource injury would be chick mortality or reduced fitness.

7. Response efforts, including the capture and rehabilitation of impaired birds, could have kept breeding birds from properly incubating eggs or tending to chicks. The natural resource injury would be chick/egg mortality.

Generally, birds in the northern Gulf of Mexico either nest in breeding colonies or build solitary nests along the coast. Direct quantification of the loss of 2010 fledglings due to the oil spill (i.e., tallying chick carcasses collected), particularly those fledglings associated with breeding colonies, was complicated by the following factors.

1. Teams searching for bird carcasses were prohibited from visiting breeding colonies for most of the breeding season, in order to limit the disturbance to already stressed birds. Thus, several breeding colonies were generally not searched with the frequent, repetitive search effort that would have generated input data for the Shoreline Deposition Model. In addition, searches that did occur at colonies were limited to observations from the perimeter of the colony, often from boats just offshore of colony islands. Information from the interior of the colonies could not be obtained.

2. Generally, even in the absence of an oil spill, not all hatched chicks will survive to fledging. "Background chick mortality" is not well characterized for bird colonies in the spill area. Thus, even if routine searches for dead chicks in breeding colonies could have been performed throughout the breeding season, the proportion attributable to the oil spill would be difficult to discern.

3. After most nesting and chick rearing activity had been completed, special searches of entire colonies, interior and perimeter, were conducted in late August and September 2010 and carcasses found were collected; these were termed "colony sweeps" (USFWS 2015a). However, information was lacking on searcher efficiency and carcass persistence values specific to the interior of colonies after the end of the breeding season, and this complicated the use of "colony sweep" information in estimating the lost 2010 fledglings.

4. The carcass persistence rate at a bird colony might be different than on shorelines outside a colony. Bird colonies exist in certain locations because conditions are good for caring for eggs and young, such as lower disturbance rates from humans or animal predators and scavengers. However, no data existed specific to the northern Gulf of Mexico bird colonies, and therefore, it is unknown whether

such differences exist there, and if so, in what magnitude. This complicates using the number of birds actually collected from colonies to estimate the number of dead birds that likely were really present.

5. Searcher efficiency is generally very low for small birds like young chicks (Varela, Martin, and Zimmerman 2015). However, the existing information on searcher efficiency pertains to shorelines at sandy beaches and marsh edges. The searcher efficiency in the interior of a nesting colony would likely be different, considering the vegetation and three-dimensional structure of many bird colonies (e.g., nests up off the ground in bushes/trees), but data did not exist specific to interior bird colonies in the northern Gulf of Mexico that would allow an estimation of colony-specific searcher efficiency values.

The above-listed complications hindered the ability of the Trustees to rely on the Shoreline Deposition Model to calculate the total fledglings lost in 2010 using collected chick and fledgling carcasses. Therefore, the Department developed an alternative method for quantifying lost 2010 fledglings, described in this document.

3 FEASIBILITY OF ASSESSING NATURAL RESOURCE INJURY REALIZED THROUGH DIFFERENT EXPOSURE PATHWAYS

The Trustees did not directly measure the effect of the oil spill on the productivity of colony and non-colony breeding birds in 2010 (i.e., no direct measure of the number of fledglings produced per nest). The Trustees did collect data on the numbers of birds and nests in colonies in 2010-2013 through aerial photography (Colibri Ecological Consulting and R. G. Ford Consulting Company 2015); however, the photographs cannot be used to count chicks (which would be shielded from photographic view by attendant parental birds) or fledglings (which could move away from colonies). In addition, the lack of detailed colony information from before the spill complicates the translation of the photographic information into the number of nests that may have been missing due to the oil spill.

As summarized in Section 2 (Background), there were several pathways through which exposure to oil could lead to adverse effects to adult productivity and survival of young. The types of adverse effects themselves, however, can be categorized as chick/egg mortality, chick reduced fitness, and chicks/eggs not produced. For pre-fledgling chicks, surviving to successfully fledge is dependent on adequate fitness of the chick, barring external factors such as predation and extreme weather. Thus, for purposes of this assessment, reduced chick fitness was treated as functionally equivalent to chick mortality. That resulted in two endpoints upon which to focus the quantification of natural resource injury in 2010 fledglings: chick/egg mortality and chicks/eggs not produced.

There were insufficient data available to assess injuries caused through each of the exposure pathways described in Section 2 with enough specificity to eliminate double-counting of injuries. A chick could suffer adverse effects from being exposed to oil through more than one pathway. For example, an oiled parent may transfer oil to its chick by body contact, as well as through feeding its chick contaminated prey, and a precocial chick leaving its nest soon after hatching may contact oil in its environment. If the chick died due to oil exposure, it would not be possible to determine to what degree each pathway contributed to the death. In this example, quantifying the injury through each of those pathways and then parsing out the potential double-counting would be treacherously tedious, if not impossible. Additionally, much of the supporting information that would be required to calculate injuries by most of the specific pathway was not available.

However, data were available to estimate the number of breeding-aged birds that died due to the spill and the number of birds withheld from their nests due to be being captured for rehabilitation. These birds would not be available to successfully reproduce in 2010.

Table 1 illustrates one of the major difficulties associated with assessing injuries caused through each of the exposure pathways described in Section 2—sufficient data to support quantifications were lacking. The second major difficult involved the ability to avoid or minimize double-counting of injuries. Of the seven pathways, pathways 5 and 7 had enough relevant data available from either DWH-specific studies or published scientific literature to allow quantification in ways that avoided or minimized double-counting.

Table 1: Potential pathways for oil to cause impacts to productivity, examples of the some of the data that would be required to assess injuries through each pathway, and availability of data.

	Pathway	Examples of Some of the Data Required for Assessment	Data Availability
1	Oiled breeding adults could have been sickened so that gametes were nonviable, producing an abnormally high number of nonviable eggs laid or smaller than normal clutch sizes. (natural resource injury = chicks not produced)	a) Degree of external oiling in breeding adults that would cause adverse impacts in gamete formation or alter clutch size. b) Actual clutch sizes in 2010.	a) Data do not exist for DWH oil on many of the affected bird species. b) No DWH-specific data, and insufficient published information upon which to generate assumptions.
2	Oiled breeding adults could have transferred oil to viable eggs in the nest while incubating them, causing the eggs to smother in oil or become nonviable due to oil toxicity. (natural resource injury = egg mortality)	a) Degree of oil transfer from parents to eggs (both how much oil is transferred and % of eggs in clutch that received oil).	a) No DWH-specific data, and insufficient published information upon which to generate assumptions.
3	Oiled breeding adults could have transferred oil to hatched chicks through physical contact, exposing chicks to oil toxicity. (natural resource injury = chick mortality or reduced fitness)	a) Degree of oil transfer from parents to chicks (both how much oil is transferred and % of chicks in nest that received oil).	a) No DWH-specific data, and insufficient published information upon which to generate assumptions.
4	Breeding adults could have fed chicks contaminated prey that could have caused toxic effects in the chicks. (natural resource injury = chick mortality or reduced fitness)	a) Number of chicks receiving toxic doses of oil in their food.	a) No DWH-specific data, and insufficient published information upon which to generate assumptions.

5	Breeding adults could have died from spill-related causes at any time during their breeding cycle, leaving eggs or chicks less able to survive. (natural resource injury = chick/egg mortality)	a) Number of breeding adults that died due to the spill. b) Likelihood that chick won't survive unless both parents are present.	a) DWH-specific data available. b) Reasonable assumptions can be made from data available from scientific literature.
6	Pre-fledging chicks could have been exposed to oil in their environment while loafing outside their nests, causing toxicity. (natural resource injury = chick mortality or reduced fitness)	a) Actual number of pre-fledging chicks in 2010.	a) No DWH-specific data available, and insufficient published information upon which to generate assumptions.
7	Response efforts, including the capture and rehabilitation of impaired birds, could have kept breeding birds from properly incubating eggs or tending to chicks. (natural resource injury = chick/egg mortality)	a) Number of breeding adults that were captured for rehabilitation.	a) DWH-specific data available.

4 METHOD FOR QUANTIFICATION OF LOST 2010 FLEDGLINGS

The Department's preferred method for estimating the lost 2010 fledglings, given the available data, was to estimate the number of fledglings that would have been produced in 2010 had breeding-aged adults not died due to the spill (pathway 5 from Table 1) or had not been kept from their nests due to being captured for rehabilitation (pathway 7). To these adult birds, the published average annual productivity rates for the affected species is applied, providing the number of fledglings that should have been produced had the breeding adults not been killed or not been captured for rehabilitation (Figure 1). The major assumption in this approach is that, but for the spill, the dead breeding adults and breeding birds captured for rehabilitation would have produced fledglings consistent with species-specific, published, average productivity rates. The application of the methodology is more complex than this conceptual model. The specific data inputs and assumptions necessary to implement the methodology are described below.

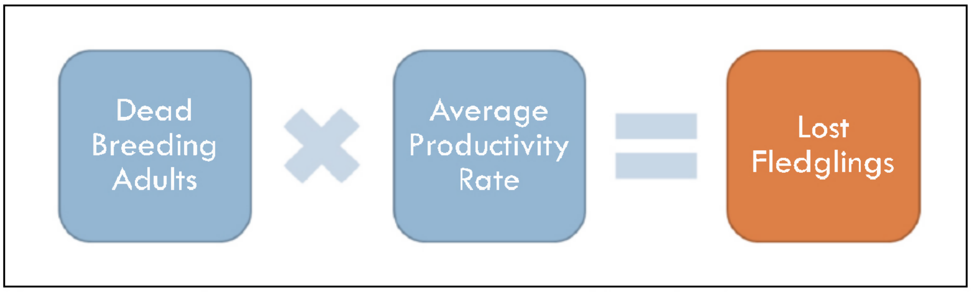

Figure 1: Conceptual approach to calculating the lost 2010 fledglings using the average annual productivity. Note, breeding birds that were captured for rehabilitation during the breeding season are considered functionally equivalent to dead birds, in that parental birds were not available to care for eggs/chicks. Thus, the "dead breeding adults" input includes birds captured and successfully rehabilitated.

4.1 ASSUMPTIONS

The following assumptions simplified the calculation of lost 2010 fledglings.

4.1.1 But for the spill, the dead breeding adults and breeding birds captured for rehabilitation would have produced fledglings consistent with species-specific, published, average productivity rates.

Productivity information specific to the northern Gulf of Mexico is not available for all avian species impacted by the spill. Gulf-specific information was used whenever available, but in some situations, it was assumed that data from other geographic areas were sufficient for use in this calculation of lost fledglings. Many published studies did not describe the environmental conditions that may have influenced productivity during the study. Therefore, it was necessary to assume that the environmental conditions that influence avian productivity were sufficiently comparable between the northern Gulf of Mexico and the locations from which the productivity information were obtained. But for the spill, productivity would have been consistent with published, average productivity rates.

4.1.2 Chicks require both parents in order to survive to fledging

For the species most affected by the spill, published scientific literature on the effect of the loss of one parent on the survival of pre-fledging birds was not available. However, literature was available on whether both parents participated in care of the eggs and rearing of the chicks.

Parental care in waterbirds, as in most birds, is shared by both members of the pair (Buckley and Buckley 2002; Burger 2015; Fasola and Saino 1995; Shields 2014). Both parents incubate the eggs and provision the young. In the early phases of nesting one bird must always remain at the nest incubating eggs or brooding small young. If one member of the pair is delayed or should fail to return to the nest, the remaining adult will eventually be forced to abandon the eggs or small young in order to forage for itself and ensure its own survival. Parental birds continue to share the burden of chick-rearing as the young grow by providing food for nestlings until they fledge and become independent. Loss of a provisioning parent would likely result in loss of pre-fledging young.

4.1.3 Had breeding birds lived, they would have attempted to rear only one clutch of eggs or brood of chicks in 2010

The avian breeding season in the warm northern Gulf of Mexico area is relatively long. Although some species of birds could have enough time to successfully rear two broods of chicks if optimal conditions existed, the seabird species most affected by the DWH spill do not attempt a second nest if the first nest is successful (brown pelican[1] (Shields 2014); laughing gull (Burger 2015); royal tern (Buckley and Buckley 2002); and black skimmer (Gochfeld and Burger 1994). However, if these seabird species experience nesting failure early in a breeding season, they may have time to re-nest and successfully rear a brood of chicks later in the breeding season (brown pelican (Shields 2014); laughing gull (Burger 2015); royal tern (Buckley and Buckley 2002); and black skimmer (Gochfeld and Burger 1994). In the scenario of the DWH spill, breeding birds could have experienced spill-related disturbances throughout most of the breeding season. Brown pelican is one of the species that begins nesting relatively early in the breeding season in the northern Gulf of Mexico, with egg laying beginning as early as March in colonies near Louisiana (Shields 2014). Breeding for brown pelicans requires about 16 weeks to complete, from the start of egg laying to fledging of young (Shields 2014). Thus, early brown pelican nests would not fledge young until approximately June/July (during a time of heavy spill-related impacts). From this example, it is not likely

[1] A list of scientific names for the bird species mentioned in this report is located in Appendix A.

that early nesting birds in 2010 had enough time to fledge young before potentially experiencing spill-related impacts. It is also likely that, if birds attempted to re-nest in 2010 after an early nest failed due to spill-related impacts, the later attempt would also be unsuccessful in fledging young due to spill-related impacts. It is not known how many, if any, of the impacted breeding birds attempted to re-nest and how many re-nest attempts per breeding pair were made. For purposes of simplifying the estimation of lost 2010 fledglings, the Department assumed that all species of breeding birds only attempted to rear one clutch of eggs or one brood of chicks to fledgling in 2010.

4.2 CALCULATION INPUTS

There two general categories of inputs to the lost 2010 fledgling estimation: the number of dead breeding adults and productivity information.

4.2.1 Number of breeding adults killed

The lost fledgling calculations started with the number of breeding birds relevant to the 2010 breeding season that were killed or were captured for rehabilitation. For purposes of the calculation of lost 2010 fledglings, all birds captured for rehabilitation were treated as dead birds even if such birds were eventually released back into the wild. This was because captured birds were not able to tend to eggs or chicks while in rehabilitation, likely resulting in the death of the eggs or chicks. The birds captured for rehabilitation were included in the DWH Collected Birds Dataset and thus were included in the Shoreline Deposition Model mortality estimates.

The number of breeding-aged birds relevant to the 2010 breeding season was derived from the avian mortality that occurred from the start of the spill to September 30, 2010 in the nearshore area of the northern Gulf of Mexico, as estimated through two additive assessment methods:

1) the Shoreline Deposition Model (IEc 2015a), and
2) the Excluded Regions methodology (USFWS 2015b), which estimated the mortality in the geographic regions not included in the Shoreline Deposition Model.

The Department estimated mortality of birds occurring in the offshore region (greater than 40 km from shore) of the northern Gulf of Mexico (IEc 2015b) in July and August 2010. The species most impacted were Audubon's shearwater, black tern, royal tern, sooty tern, and laughing gull. However, these birds were not included in the lost 2010 fledgling calculation, primarily because there was no age information available that would allow identifying the portion of those killed that was likely of breeding age.

A few adjustments to these two outputs were required to isolate the "base number" of dead breeding birds (DBB_{2010}) for the calculation of 2010 lost fledglings. In short, the two mortality quantification outputs (the sum of the outputs = M_{2010}) were adjusted to exclude species that may not have suffered reproductive impacts (L) and exclude birds that died after the breeding season ended (AFS_{2010}). To this adjusted mortality estimate, the proportion consisting of breeding birds (PB_{CBD}), derived from the DWH Collected Birds Dataset, was applied to obtain the number of breeding birds subject to the lost fledgling calculation.

$$(M_{2010} - L - AFS_{2010}) * PB_{CBD} = DBB_{2010}$$

These adjustments are further described below.

For the sake of simplifying the lost 2010 fledgling calculation, only the species with the highest mortality estimates in the Shoreline Deposition Model were considered. These 14 species cumulatively comprised up to 91% of the Shoreline Deposition Model output. The remaining 9% of the mortality was distributed among over 70 species.

4.2.1.1 Number of breeding adults derived from the output of the Shoreline Deposition Model

The Shoreline Deposition Model estimated the total bird mortality during the time period of May through September 2010 for nearshore areas within the northern Gulf of Mexico using the DWH Collected Birds Dataset[2] as one of the main inputs (IEc 2015a). In order to isolate the portion of DBB_{2010} that is derived from the Shoreline Deposition Model output, the following adjustments were made.

4.2.1.1.1 Excluded species in which the breeding-aged adults would have left the spill area before exposure to oil

Several bird species spend the winter in the northern Gulf of Mexico but migrate to breeding grounds in the spring. Species that breed in areas outside of the northern Gulf of Mexico could experience spill-related impacts to reproductive success if they were exposed to oil before migrating. However, there are a few species represented in the DWH Collected Birds Dataset whose breeding adults should have left the spill area in April 2010 before their risk of exposure to oil in 2010 was great (L), as surmised by what is known of their specific life histories and published literature. Radiotelemetry studies on northern gannets and common loons provided evidence that these species likely left the Gulf of Mexico, migrating to northern breeding grounds, before exposure to *Deepwater Horizon* oil (Montevecchi et al. 2011, Paruk et al. 2014). Therefore, this lost 2010 fledgling calculation did not include these species, because those birds included as inputs to the Shoreline Deposition Model were most likely non-breeding birds.

4.2.1.1.2 Excluded mortalities occurring after the end of the 2010 fledging season

The duration of the nesting season for birds in the northern Gulf of Mexico varies among species. In general, nesting seasons begin for many species in early spring (roughly March), and young are generally fledged by mid-summer (roughly August). The Shoreline Deposition Model results include birds that died after the end of the 2010 fledging season (i.e., birds that did not die or did not become incapacitated enough to allow capture until after the season during which the birds could have successfully fledged young in 2010). The Trustees have no data on how long these birds may have been exposed to oil before they died or were captured, and by extension, no information on what proportion of these birds may have experienced impacts to reproductive success. However, the Department assumes that all birds that died or were captured for rehabilitation after mid-summer (assumed for modeling purposes to be August 7, 2010) (AFS_{2010}) could have successfully fledged chicks at average rates during the 2010 breeding season and should be excluded from the lost 2010 fledgling calculations. This assumption may result in an underestimate of lost 2010 fledges if breeding adults experienced reduced fitness for an extended amount of time before dying or before being captured for rehabilitation (i.e., reduced fitness during the breeding season). Alternatively, this assumption might generate an overestimation of lost 2010 fledges if the end of the fledgling season was sooner than August (i.e., more birds were alive to successfully rear chicks to fledging).

[2] DWHBirdsCollected_DraftValidated_8.28.15.xlsx

To obtain the value of AFS_{2010}, the Shoreline Deposition Model output was truncated at August 7, 2010. The difference between the Model's output for the May-September period and the truncated output is equal to AFS_{2010}.

Note that "colony sweep" birds were not considered during the calculation of lost 2010 fledglings. These birds were collected in late August and September 2010, but they may have died some unknown amount of time earlier. There were insufficient data to determine what portion of the "colony sweep" birds may have died before the August 7 end of the fledging season (e.g., no information was available for carcass persistence rates within colonies). Therefore, for purposes of simplifying the calculation of lost 2010 fledglings, the Department assumed that all of the breeding-aged "colony sweep" birds were able to fledge a normal number of young in 2010.

Also note that, while "colony sweep" birds and birds that died after August 7, 2010 were not used in the lost 2010 fledgling calculations, they were used in the calculation of lost 2011 fledglings.

4.2.1.1.3 Isolated the breeding birds from the Shoreline Deposition Model mortality estimate by age class

The inputs to the Shoreline Deposition Model included bird records from the DWH Collected Birds Dataset regardless of age class. In other words, some dead 2010 fledglings (and other birds younger than breeding age) were collected and were listed in the DWH Collected Birds Dataset. The Shoreline Deposition Model used all of these birds to calculate avian mortality, because the Model considers each bird collected as representing some number of other birds not collected, applying a multiplier to collected birds to estimate total mortality. Each chick or fledgling in the DWH Collected Birds Dataset potentially represents other similarly sized birds (regardless of age class) that were not collected. The output of the Shoreline Deposition Model is in terms of generic "birds," without reference to age. In order to allocate the Model's output into age classes, considering the lack of better information, the Department applied a pro-rating methodology using age class information from the DWH Collected Birds Dataset.

The DWH Collected Birds Dataset contains a data field for age class for each collected bird. Potential values included the following:

- Adult – Of breeding age. Not necessarily in breeding plumage.
- Juvenile – Younger than breeding age.
- After Hatch Year – Older than one year of age. Could include both juveniles and breeding adults.
- Hatch Year – Younger than one year of age.
- N/D – No data available or age could not be discerned.

From the age class information, the proportion of each age class within a species was identified considering only the bird records for which age class was identified and excluding records that were not used in the Shoreline Deposition Model[3] and records dated after August 7, 2010. Although birds

[3] The DWH Collected Birds Dataset contains a data field that facilitates the identification of bird records that were and were not used as input in the Shoreline Deposition Model. An example of a category of birds excluded from the Model are birds that were collected outside of the geographic area within which bird mortality was being estimated by the Model. See the "data dictionary" for the DWH Collected Birds Dataset for additional information (IEc 2015c).

recorded as "After Hatch Year" may have included some breeding-aged birds, the proportion of breeding-aged birds in this group was unknown. Thus, only the bird records classified as "Adult" were used to estimate PB_{MBS} (PB_{MBS} = # breeding-aged birds ÷ total number of birds of known age). The proportions of breeding-aged birds are listed in Table 2.

Table 2: Proportions of breeding-aged birds derived from the DWH Collected Birds Dataset (CBD), considering only the bird records for which age class was identified, excluding all records not used in the Shoreline Deposition Model, and excluding records dated after August 7, 2010.

Species	# birds with known age class in CBD	# birds known to be of breeding age in CBD	% breeding adults (PB_{CBD})
American white pelican	36	28	77.8%
Black skimmer	92	6	6.5%
Brown pelican	862	451	52.3%
Cattle egret	21	17	81.0%
Clapper rail	15	6	40.0%
Double-crested cormorant	12	6	50.0%
Forster's tern	28	2	7.1%
Great blue heron	37	21	56.8%
Laughing gull	1,640	480	29.3%
Least tern	69	22	31.9%
Roseate spoonbill	21	6	28.6%
Royal tern	182	73	40.1%
Sandwich tern	51	28	54.9%
Tricolored heron	33	8	24.2%

4.2.1.2 Number of breeding adults derived from the output of the Excluded Regions methodology

Three regions within the larger geographic area assessed by the Shoreline Deposition Model (Lake Mechant, LA, Vermilion Bay, LA, and Breton-Chandeleur Islands, LA) lacked sufficient search effort and carcass collection data to enable using the Model to develop mortality estimates for those regions. The Department developed an alternative method to estimate bird mortality in those regions, which consisted of applying mortality rate information (# birds killed per kilometer of shoreline) from similar or adjacent regions that were assessed by the Model to those regions not assessed (USFWS 2015b).

To isolate the number of dead breeding-aged birds from the mortality information derived from the Excluded Regions methodology, the output was adjusted using the same steps as for the Shoreline Deposition Model output, with the following clarifications. The same species considered to have left before oil exposure would have impacted their reproduction were removed from the Excluded Regions output. In order to identify the number of birds that died after August 7, 2010, the Excluded Regions calculation was truncated at August 7, 2010. The difference between the full Model output and the truncated output equaled the portion that died after the fledging season had ended. The age class proportions developed for adjusting the Shoreline Deposition Model output also were applied to the Excluded Regions output.

Table 3: Number of dead breeding adults (DBB_{2010}) isolated from the Shoreline Deposition Model output (low and high ends of range shown). Only the species with the highest mortality estimates in the SDM and that cumulatively comprised up to 91% of the SDM output are shown. (Some values may not sum exactly as shown due to numerical rounding issues.)

Species	SDM output (# birds killed, all ages) (M_{2010})		Portion of SDM output occurring after the end of the 2010 fledging season (# birds killed, all ages) (AFS_{2010})		Portion of SDM output occurring before August 8, 2010 (M_{2010} - AFS_{2010})		# breeding adults killed derived from SDM output (DBB_{2010})	
	low	high	low	high	low	high	low	high
American white pelican	238	358	83	133	155	225	121	175
Black skimmer	1,015	1523	353	565	662	958	43	62
Brown pelican	7,105	10,663	2,472	3,958	4,634	6,705	2,424	3,508
Cattle egret	264	396	92	147	172	249	140	202
Clapper rail	347	521	121	193	226	327	91	131
Double-crested cormorant	274	412	95	153	179	259	89	130
Forster's tern	269	404	94	150	176	254	12	18
Great blue heron	331	497	115	185	216	313	123	178
Laughing gull	19,637	29,471	6,831	10,939	12,806	18,532	3,748	5,424
Least tern	642	964	223	358	419	606	134	193
Roseate spoonbill	218	326	76	121	142	205	41	59
Royal tern	2,061	3,093	717	1,148	1,344	1,945	539	780
Sandwich tern	513	769	178	286	334	484	184	266
Tricolored heron	249	373	86	138	162	235	39	57
Total	33,164	49,772	11,536	18,474	21,628	31,298	7,727	11,182

Table 4: Number of dead breeding adults (DBB_{2010}) isolated from the Excluded Regions output (low and high ends of range shown). Only the species with the highest mortality estimates in the SDM and that cumulatively comprised up to 91% of the SDM output are shown. (Some values may not sum exactly as shown due to numerical rounding issues.)

Species	Excluded Regions output (# birds killed, all ages) (M_{2010})		Portion of Excluded Regions output occurring after the end of the 2010 fledging season (# birds killed, all ages) (AFS_{2010})		Portion of Excluded Regions output occurring before August 8, 2010 (M_{2010} - AFS_{2010})		# breeding adults killed, derived from Excluded Regions output (DBB_{2010})	
	low	high	low	high	low	high	low	high
American white pelican	22	43	7	13	15	30	11	23
Black skimmer	92	182	28	56	64	127	4	8
Brown pelican	642	1,277	196	389	446	888	234	465
Cattle egret	24	47	7	14	17	33	13	27
Clapper rail	31	62	10	19	22	43	9	17
Double-crested cormorant	25	49	8	15	17	34	9	17
Forster's tern	24	48	7	15	17	34	1	2
Great blue heron	30	60	9	18	21	41	12	24
Laughing gull	1,775	3,530	542	1,076	1,234	2,453	366	729
Least tern	58	115	18	35	40	80	13	26
Roseate spoonbill	20	39	6	12	14	27	4	9
Royal tern	186	370	57	113	129	257	52	103
Sandwich tern	46	92	14	28	32	64	18	35
Tricolored heron	22	45	7	14	16	31	4	8
total	2,998	5,961	915	1,818	2,083	4,143	750	1,492

4.2.2 *Translating # dead breeding birds to # affected pairs*

Published average annual productivity data are generally presented in units of "fledglings per nest," "fledglings per pair," or "fledglings per female." The number of dead breeding birds (DBB_{2010}) for the 2010 lost fledglings calculation is in units of breeding-aged individuals, without regard to gender. Thus, DBB_{2010} must be translated into a metric consistent with that of the average annual productivity value. The logical metric to use was "per pair" after considering the following:

- If one assumes that birds only attempt to rear one brood per year (Section 4.1.3), "fledglings per nest" and "fledglings per pair" are functionally equivalent.
- The Department assumed that chicks required care from both parents in order to survive to fledging (Section 4.1.2). In other words, if one parent was absent due to the spill, all of its pre-fledged chicks would perish.
- If productivity values that focus on breeding females ("fledglings per female") were used, the lost fledgling calculation would in turn focus on lost breeding-aged females. Assuming a 50:50 sex ratio, the number of affected pairs would equal 1/2 of DBB_{2010}. However, fledglings would also be lost in nests where the female may have survived but the male perished.

It is theoretically possible, although unlikely, that every individual comprising DBB_{2010} could have paired with a mate that did not perish during the 2010 breeding season (DBB_{2010} = # of affected pairs). The true number of affected pairs (AP_{2010}) to be used in the calculation of lost 2010 fledglings was not known; however, it was must be somewhere between DBB_{2010} and ½ of DBB_{2010}. For a lack of better information, the midpoint between these two values was used as a point-estimate of the number of affected pairs (AN_{2010} = 3/4 of DBB_{2010}), with DBB_{2010} and ½ of DBB_{2010} used as the maximum and minimum values of a range. The revised conceptual calculation is shown below.

$$0.75 * DBB_{2010} = AP_{2010} \quad \text{(mid-point estimate)}$$

$$AP_{2010} * Productivity = LostFledglings_{2010}$$

4.2.3 *Average annual productivity*

The relevant productivity values are listed in Table 5. For the sake of simplifying the lost fledgling calculation, only the species with the highest mortality estimates in the SDM and that cumulatively comprised up to 91% of the SDM output are shown.

4.3 POTENTIAL BIASES IN APPROACH

This method to quantifying lost 2010 fledglings did not account for all of the potential pathways to natural resource injuries that were listed in Section 2. For instance, the spill-related mortality or non-production of eggs and chicks of parent birds that did not suffer *acute* mortality or *were not* captured for rehabilitation. The method also did not quantify lost fledglings due to exposure of eggs or chicks to oil. Many of these pathways listed in Section 2 may have overlapped to contribute to the same lost fledglings. Considering those factors, the preferred methodology would likely produce an underestimate of lost fledglings. However, there were also uncertainties associated with all of the assumptions employed in this methodology, for which the magnitude and direction of the potential bias were unknown. In addition, the background amount of chick mortality (i.e., amount of mortality that would have naturally occurred in the absence of the spill) has not been removed from the calculation results, since such background mortality information was unknown. The August 7, 2010 date used to signify the end of the fledging season may result in an underestimate of lost 2010 fledges if breeding adults experienced reduced fitness for an extended amount of time before dying or before being captured for rehabilitation (i.e., reduced fitness during the breeding season). Alternatively, this assumption might generate an overestimation of lost 2010 fledges if the end of the fledgling season was sooner than August (i.e., more birds were alive to successfully rear chicks to fledging). The "hatch year" age category included fledglings and pre-fledgling age classes, the proportions of which were unknown, and this calculation treated all hatch year birds as fledglings, which would likely have tended toward an overestimation of fledglings lost due to the spill.

The lost 2010 fledglings calculation focused on the 14 species that had the highest mortalities calculated by the Shoreline Deposition Model. Cumulatively, they comprised up to 91% of the Model's output. The remaining 9% of the mortality spanned over 70 species. As the lost 2010 productivity associated with these birds was not estimated, this would contribute to the total lost 2010 fledgling estimate being an underestimate. In addition, the lost fledglings associated with birds estimated to have died through the Offshore Exposure Model was not calculated.

The primary sources of data for the lost 2010 fledgling calculation were the outputs of the Shoreline Deposition Model and the "Excluded Regions" method (which also was rooted in the output of the Shoreline Deposition Model). As such, all of the limitations and uncertainties associated with the outputs of those models also apply to the lost 2010 fledgling results. These are described in the technical reports for those models (IEc 2015a, USFWS 2015b). To the extent these models likely underestimated adult bird mortality, the lost 2010 fledgling calculation would likely also be underestimated.

Lastly, the methodology used here was limited to calculating the fledglings lost during the *first* year that a breeding-aged bird was not able to successfully reproduce. In other words, for birds that died during the 2010 breeding season, only the lost productivity from that breeding season was quantified. Theoretically, the breeding-aged birds that died during the 2010 breeding season, had they not been killed, could have reproduced in later years. Calculating that additional lost productivity required additional assumptions on life history parameters and population dynamics modeling, which could not be completed for administrative reasons—the announcement of the natural resource damages Agreement in Principle between BP and the Trustees created a sudden significant shortening of the time the Department had available to complete injury quantification tasks. This contributes to an underestimate of the total fledglings lost due to birds that died during the 2010 breeding season.

Overall, considering all of the abovementioned factors combined, the limitations and uncertainties would likely contribute to an overall underestimate of fledglings lost in 2010 due to the spill. Given the available information, the results presented here are the Department's best estimate of fledglings lost in 2010 due to the spill, recognizing that the true loss is likely higher by some unquantifiable amount.

Table 5: Average annual productivity values (# fledglings per pair per year, assuming one brood per year).

Species	Average annual productivity	References / Notes
American white pelican	0.76	IEc 2014
Black skimmer	0.22	Clark et al. 2013; Fitzsimmons and Newstead 2015; Pruner et al. 2011
Brown pelican	1.44	IEc 2014
Cattle egret	1.77	Ranglack, Angus, and Marion 1991; Rodgers 1987; Telfair 2006
Clapper rail	5.5	IEc 2014
Double-crested cormorant	1.79	IEc 2014
Forster's tern	0.6	King, Custer, and Quinn 1991
Great blue heron	0.35	IEc 2014
Laughing gull	0.97	IEc 2014
Least tern	0.6	Thompson and Slack 1984; Thompson et al. 1997
Roseate spoonbill	1.44	Lorenz et al. 2009; White et al. 1982
Royal tern	0.42	Owen and Pierce 2014
Sandwich tern	0.41	Owen and Pierce 2014
Tricolored heron	0.9	Frederick 2013; Frederick and Collopy 1989; Frederick, Spalding, and Powell 1993

5 RESULTS FROM PREFERRED METHODOLOGY

Using the information described above, the total numbers of lost 2010 fledglings are shown in Table 6.

Table 6: Total lost 2010 fledglings (low and high end of range). (Some values may not sum exactly as shown due to numerical rounding issues.)

	# dead breeding birds, from SDM and Excluded Regions combined (DBB_{2010})		# affected pairs (AP_{2010})		# lost 2010 fledglings	
Species	low	high	low	high	low	high
American white pelican	132	198	66	198	50	150
Black skimmer	47	71	24	71	5	16
Brown pelican	2,658	3,973	1,329	3,973	1,914	5,721
Cattle egret	153	229	76	229	135	405
Clapper rail	99	148	50	148	273	816
Double-crested cormorant	98	147	49	147	88	263
Forster's tern	14	20	7	20	4	12
Great blue heron	135	201	67	201	24	70
Laughing gull	4,114	6,153	2,057	6,153	1,995	5,969
Least tern	146	219	73	219	44	131
Roseate spoonbill	45	68	22	68	32	97
Royal tern	591	883	295	883	124	371
Sandwich tern	201	301	101	301	41	123
Tricolored heron	43	64	22	64	19	58
total	8,476	12,675	4,238	12,675	4,748	14,202

6 MERGING RESULTS OF SHORELINE DEPOSITION MODEL, "EXCLUDED REGIONS" METHOD, AND LOST FLEDGLING CALCULATIONS

The number of lost fledglings cannot be simply added to the outputs of the Shoreline Deposition Model and Excluded Regions estimation to yield a total mortality estimate, because a portion of the total number of lost fledglings is already included in those outputs.

In order to determine the number of fledglings already addressed in the outputs of the Shoreline Deposition Model and Excluded Regions estimation, the DWH Collected Birds Dataset was used to identify species-specific proportions of that dataset that were hatch year birds, using only the bird records for which age class was identified and excluding all records not used in the Shoreline Deposition Model (Table 7). Because the Shoreline Deposition Model and "Excluded Regions" estimate spanned from the beginning of the spill to September 30, 2010, within which the number of fledglings already included needed to be identified, the species-specific proportions of hatch year birds was generated using DWH Collected Birds Dataset records spanning from the beginning of the spill to September 30, 2010. These proportions were applied to the outputs of the Shoreline Deposition Model and the Excluded Regions estimation to identify the number of hatch year birds already included in those mortality estimates (Table 8).

In conclusion, 4,748 to 14,202 fledglings were lost in 2010 due to the deaths of breeding-aged birds occurring from the beginning of the spill to August 7, 2010 (Table 6). In other words, 1,749 to 6,345 fledglings, in addition to those already accounted for by the Shoreline Deposition Model and Excluded Regions estimation, were lost in 2010 (Table 8).

Table 7: Proportion of hatch year birds in DWH Collected Birds Dataset (CBD), considering only the bird records for which age class was identified and excluding all records not used in the Shoreline Deposition Model (SDM).

Species	# birds with known age class in CBD	# birds known to be hatch year in CBD	% hatch year
American white pelican	38	0	0%
Black skimmer	156	89	57.1%
Brown pelican	1016	85	8.4%
Cattle egret	25	0	0%
Clapper rail	35	4	11.4%
Double-crested cormorant	22	3	13.6%
Forster's tern	35	7	20.0%
Great blue heron	42	3	7.1%
Laughing gull	2503	680	27.2%
Least tern	74	34	45.9%
Roseate spoonbill	21	1	4.8%
Royal tern	268	47	17.5%
Sandwich tern	72	9	12.5%
Tricolored heron	33	8	24.2%

Table 8: Number of hatch year birds already included in the outputs of the Shoreline Deposition Model (SDM) and Excluded Regions method, and the numbers of fledglings estimated to have died in addition to the outputs of the Shoreline Deposition Model and Excluded Regions method. (Some values may not sum exactly as shown due to numerical rounding issues.)

Species	# hatch year birds killed, already included in SDM output		# hatch year birds killed, already included in Excluded Regions output		Total # lost fledglings in addition to the SDM and Excluded Regions outputs	
	low	high	low	high	low	high
American white pelican	0	0	0	0	50	146
Black skimmer	580	870	52	104	0	0
Brown pelican	594	892	54	107	1,266	4,718
Cattle egret	0	0	0	0	135	405
Clapper rail	40	59	4	7	230	749
Double-crested cormorant	37	56	3	7	47	200
Forster's tern	54	81	5	10	0	0
Great blue heron	24	35	2	4	0	31
Laughing gull	5335	8007	481	957	0	0
Least tern	295	442	27	53	0	0
Roseate spoonbill	10	15	1	2	21	80
Royal tern	361	541	33	65	0	0
Sandwich tern	64	96	6	12	0	16
Tricolored heron	60	90	5	11	0	0
totals	7,454	11,184	673	1,339	1,749	6,345

7 REFERENCES

Buckley, P. A. and Francine G. Buckley. 2002. Royal Tern (*Thalasseus maximus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/700 doi:10.2173/bna.700. Accessed July 29, 2015.

Burger, Joanna. 2015. Laughing Gull (*Leucophaeus atricilla*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/225 doi:10.2173/bna.225. Accessed July 29, 2015.

Clark, Rick, Monica Hardin, Rebecca Carruth, Toby Stapleton, Jordan Smith, Gary Hopkins, Jeffrey Sloane, Amy Hammesfahr, James R. Hess, and John Gibson. 2013. 2013 Comprehensive Shorebird Nesting Summary and Year One Progress Report, DWH/MC252 Avian Conservation Habitat Project Tiered to the BP Early Framework Restoration Agreement. National Park Service.

Colibri Ecological Consulting and R. G. Ford Consulting Company. 2015. Analysis of 2010–2013 Photographic Census Data from Waterbird Breeding Colonies in the Vicinity of the *Deepwater Horizon* Oil Spill. Draft Final Report. Prepared for the U.S. Fish and Wildlife Service. August 2015.

Fasola, Mauro, and Nicola Saino. 1995. Sex-biased parental-care allocation in three tern species (Laridae, Aves). *Canadian J. of Zool.* 73(8):1461-1467 doi: 10.1139/z95-172. Accessed June 6, 2013.

Fitzsimmons, Owen N., and David J. Newstead. 2015. The use of game cameras to monitor Black Skimmer colonies in Texas. Poster presented at 39th Annual Meeting of the Waterbird Society. August 11-15. 2015. Bar Harbor, Maine.

Frederick, Peter C. 2013. Tricolored Heron (Egretta tricolor), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/306 doi:10.2173/bna.306. Accessed August 2, 2015.

Frederick, Peter C., and Michael W. Collopy. 1989. Nesting Success of Five Ciconiiform Species in Relation to Water Conditions in the Florida Everglades. *Auk* 106(4):625-634. Stable URL: http://www.jstor.org/stable/4087667 Accessed August 4, 2015.

Frederick, P. C., M. G. Spalding, and G. V. N. Powell. 1993. Evaluating methods to measure nestling survival in Tricolored Herons. *J. Wildl. Manage*. 57:34-41. Article DOI: 10.2307/3808997
Stable URL: http://www.jstor.org/stable/3808997 Accessed August 4, 2015.

IEc (Industrial Economics, Inc.). 2014. Avian Life History Information for Focus Bird Species Using the Northern Gulf of Mexico. Draft Final April 29, 2014.

IEc. 2015a. *Deepwater Horizon*/Mississippi Canyon Oil Spill Natural Resource Damage Assessment Technical Report: Quantification of Nearshore Avian Mortality using the Shoreline Deposition Model and Lost at Sea Factor. Prepared for the Deepwater Horizon Natural Resource Damage Assessment and Restoration Program, U.S. Fish and Wildlife Service, U.S. Department of the Interior. September 1, 2015.

IEc. 2015b. *Deepwater Horizon*/Mississippi Canyon Oil Spill Natural Resource Damage Assessment Technical Report: Estimating the offshore mortality of birds killed by DWH oil. Prepared for the Deepwater Horizon Natural Resource Damage Assessment and Restoration Program, U.S. Fish and Wildlife Service, U.S. Department of the Interior. August 31, 2015.

IEc. 2015c. Data Verification and Validation Report for: *Deepwater Horizon* (DWH) Collected Birds Dataset. August, 2015.

King, Kirke A., Thomas W. Custer, and James S. Quinn. 1991. Effects of mercury, selenium, and organochlorine contaminants on reproduction of Forster's Terns and Black Skimmers nesting in a contaminated Texas bay. *Arch. Environ. Contam. Toxicol.* 20:32-40. Accessed online August 2, 2015. http://link.springer.com/article/10.1007/BF01065325# doi 10.1007/BF01065325.

Lorenz, Jerome J., Brynne Langan-Mulrooney, Peter E. Frezza, Rebecca G. Harvey, and Frank J. Mazzotti. 2009. Roseate spoonbill reproduction as an indicator for restoration of the Everglades and the Everglades estuaries. *Ecol. Indicators* 9(6, Suppl.):S96-S107. doi:10.1016/j.ecolind.2008.10.008

Montevecchi, William, David Fifield, Chantelle Burke, Stefan Garthe, April Hedd, Jean-Francois Rail, and Gregory Robertson. 2011. Tracking long-distance migration to assess marine pollution impact. *Biol. Lett.* published online 19 October 2011. http://rsbl.royalsocietypublishing.org/content/8/2/218 DOI: 10.1098/rsbl.2011.0880. Accessed July 29, 2015.

Owen, Tabitha M., and Aaron R. Pierce. 2014. Productivity and Chick Growth Rates of Royal Tern (*Thalasseus maximus*) and Sandwich Tern (*Thalasseus sandvicensis*) on the Isles Dernieres Barrier Island

Refuge, Louisiana. *Waterbirds* 37(3):245-253. Accessed August 20, 2015. http://www.bioone.org/doi/full/10.1675/063.037.0303 DOI: http://dx.doi.org/10.1675/063.037.0303

Paruk, J. D., D. Long IV, S. L. Ford, and D. C. Evers. 2014. Common loons (*Gavia immer*) wintering off the Louisiana coast tracked to Saskatchewan during the breeding season. *Waterbirds* 37(sp1):47-52.

Pruner, Raya A., Marvin J. Friel, and Jared A. Zimmerman. 2011. Interpreting the influence of habitat management actions on shorebird nesting activity at coastal state parks in the Florida panhandle. 2010-2011 study final report. Department of Environmental Protection, Florida Park Service.

Ranglack, Georganna S., Robert A. Angus, and Ken R. Marion. 1991. Physical and Temporal Factors Influencing Breeding Success of Cattle Egrets (Bubulcus ibis) in a West Alabama Colony. Colonial Waterbirds 14(2):140-149. Stable URL: http://www.jstor.org/stable/1521503 DOI: 10.2307/1521503

Rodgers, James A., Jr. 1987. Breeding Chronology and Reproductive Success of Cattle Egrets and Little Blue Herons on the West Coast of Florida, USA. Colonial Waterbirds 10(1):38-44 . Stable URL: http://www.jstor.org/stable/1521228 DOI: 10.2307/1521228

Shields, Mark. 2014. Brown Pelican (*Pelecanus occidentalis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/609 doi:10.2173/bna.609. Accessed July 29, 2015.

Telfair II, Raymond C. 2006. Cattle Egret (*Bubulcus ibis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/113 doi:10.2173/bna.113 Accessed July 29, 2015.

Thompson, Bruce C., Jerome A. Jackson, Joannna Burger, Laura A. Hill, Eileen M. Kirsch and Jonathan L. Atwood. 1997. Least Tern (*Sternula antillarum*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online, August 4, 2015: http://bna.birds.cornell.edu/bna/species/290 doi:10.2173/bna.290

Thompson, Bruce C., and R. Douglas Slack. 1984. Post-Fledging Departure from Colonies by Juvenile Least Terns in Texas: Implications for Estimating Production. *Wilson Bull.* 96(2): 309-313. Accessed online August 2, 2015. http://www.jstor.org/stable/4161928

USFWS (U.S. Fish and Wildlife Service). 2015a. Dead Birds Collected during Colony Sweep Activities. USFWS Technical Report.

USFWS. 2015b. Estimation of Avian Mortality in Regions not Included in the Shoreline Deposition Model. USFWS Technical Report.

USFWS. 2015c. Technical Report: Quantification of Fledglings Lost in 2011. August 2015.

Varela, Veronica, Paige Martin, and Guthrie Zimmerman. 2015. Factors Influencing Searcher Efficiency for Bird Carcasses on Marsh Edges and Sandy Beaches in the Northern Gulf of Mexico. U.S. Fish and Wildlife Service.

White, Donald H., Christine A. Mitchell, and Eugene Cromartie. 1982. Nesting Ecology of Roseate Spoonbills at Nueces Bay, Texas. *Auk* 99(2):275-284. Stable URL: http://www.jstor.org/stable/4085974 Accessed August 20, 2015.

Appendix A: Common and scientific names of the bird species mentioned in the Quantification of Lost 2010 Fledglings.

Common name	Scientific name
American white pelican	*Pelecanus erythrorhynchos*
Audubon’s shearwater	*Puffinus lherminieri*
Black skimmer	*Rynchops niger*
Black tern	*Chlidonias niger*
Brown pelican	*Pelecanus occidentalis*
Cattle egret	*Bubulcus ibis*
Clapper rail	*Rallus longirostris*
Common loon	*Gavia immer*
Double-crested cormorant	*Phalacrocorax auritus*
Forster's tern	*Sterna forsteri*
Great blue heron	*Ardea herodias*
Laughing gull	*Leucophaeus atricilla*
Least tern	*Sternula antillarum*
Northern gannet	*Morus bassanus*
Roseate spoonbill	*Platalea ajaja*
Royal tern	*Thalasseus maximus*
Sandwich tern	*Thalasseus sandvicensis*
Sooty tern	*Onychoprion fuscatus*
Tricolored heron	*Egretta tricolor*